97-84010-6

Safford, Truman Henry

Development of astronomy in the United States

Williamstown, Mass.

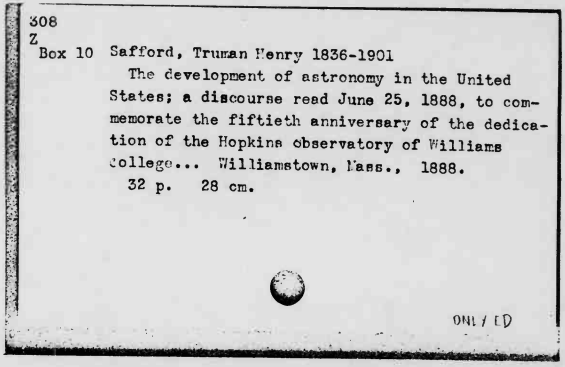
1888

97-84010-6
MASTER NEGATIVE #

COLUMBIA UNIVERSITY LIBRARIES
PRESERVATION DIVISION

BIBLIOGRAPHIC MICROFORM TARGET

ORIGINAL MATERIAL AS FILMED - EXISTING BIBLIOGRAPHIC RECORD


308
Z
Box 10 Safford, Truman Henry 1836-1901
The development of astronomy in the United States; a discourse read June 25, 1888, to commemorate the fiftieth anniversary of the dedication of the Hopkins observatory of Williams college... Williamstown, Mass., 1888.
32 p. 28 cm.
ONLY ED

RESTRICTIONS ON USE: *Reproductions may not be made without permission from Columbia University Libraries.*

TECHNICAL MICROFORM DATA

FILM SIZE: 35mm REDUCTION RATIO: 12:1 IMAGE PLACEMENT: IA (IIA) IB IIB

DATE FILMED: 1-17-97 INITIALS: JRB.

TRACKING # : 20145

FILMED BY PRESERVATION RESOURCES, BETHLEHEM, PA.

Pratt's Presents
Collection

308
Z

Box 10

COMMEMORATION

OF

THE FIFTIETH ANNIVERSARY

OF THE

DEDICATION OF THE HOPKINS OBSERVATORY

WILLIAMS COLLEGE

1888

THE DEVELOPMENT OF ASTRONOMY IN THE UNITED STATES

A DISCOURSE

READ JUNE 25, 1888

TO COMMEMORATE THE FIFTIETH ANNIVERSARY

OF THE

DEDICATION

OF THE

HOPKINS OBSERVATORY

OF

WILLIAMS COLLEGE

BY TRUMAN HENRY SAFFORD, PH. D.
FIELD MEMORIAL PROFESSOR OF ASTRONOMY

WILLIAMSTOWN, MASS
PUBLISHED BY THE COLLEGE
1888

Edn B 13 Oct 1915

DISCOURSE

ABOUT two hundred years ago Isaac Newton published his famous "Principia"; the English title is "The Mathematical Principles of Natural Philosophy." From that epoch dates modern astronomy; for the book laid down the law of universal gravitation, according to which the motions of the moon and planets are governed. The same law holds good to the remotest bounds of the universe; comets obey it in their journeys into far distant space, and double suns, in many solar systems, circle around each other in obedience to its formula.

From the discovery of this far-reaching law of nature, the most delicate and exact observations became necessary to test it; for from its very essence it must have an exact fulfilment. Observers must now carry their work to the last degree of delicacy; they must study the structure of the human eye to learn what is the highest precision attainable by the sense of sight, when aided by the best optical glasses.

Newton himself had a small observatory at Cambridge (in England), where he was a professor; but it was not to be expected that he himself should watch the heavens nightly. His mighty genius was too fully occupied with his great mathematical problems; among which is to be reckoned the invention, independently of Leibnitz, of the calculus.

Charles the Second, bad man as he was, possessed human sympathy enough to found an observatory, to preserve his sailors from shipwreck. Navigation was then extremely dangerous; there were no guides across the ocean. Such guides were to be found in a knowledge of the motions of sun, moon, and stars, to be gained by the patient labors of astronomers. So the Greenwich Observatory began; the first Astronomer Royal, a contemporary of Newton, was the Rev. John Flamsteed.

In 1705 Edmund Halley found that the great comet of 1682 was periodic, and would return in 1758; it did so return, its orbit was again calculated by others, and its next appearance predicted for 1835. As we shall see, this last coming of Halley's comet was influential in the foundation of American observatories. Halley's calculations were made to test and exemplify his great master Newton's theory, of which they furnished a brilliant example. Who will not say, when this fine comet returns in 1910 that it furnishes a new proof of the law of gravitation? In fact Newton must be considered the best astronomer of all past ages.

At Flamsteed's death Halley succeeded him as Astronomer Royal; but he was then an old man, and added little to his former reputation. James Bradley, like Flamsteed a clergyman of the Established Church, was Halley's successor; it was he who first made Greenwich Observatory what it now is, the most prominent one, all things considered, in the world. About 1750 he obtained new instruments, and began the great work of his life,—a magnificent series of meridian observations, which is indispensable to all who wish to know anything about the stellar motions, or to follow sun, moon, and planets in their apparent courses. A most eminent

living German astronomer has spent many years in recalculating Bradley's observations, and is now publishing his results.

Bradley was followed by Nathaniel Bliss, who was an indifferent observer; and in a few years by Nevil Maskelyne, who was Astronomer Royal for the half-century which began with our colonial troubles and ended with the war of 1812. Maskelyne possessed some eminent qualities as an observer, but lacked others. He discharged an assistant for noting time differently from himself; it was reserved for an abler man to find out that "personal equation" is a universal phenomenon among observers,—that no two observe times exactly alike. The poor fellow was really an excellent assistant. Maskelyne's great service was the establishment of the Nautical Almanac, the sailor's indispensable companion. The French had had something of the kind for many years, however; I have wondered whether John Paul Jones used his enemy's book in guiding his ships across the ocean, or that of our French friends, in a foreign language.

I have premised these few things about English astronomy. as our own was naturally based upon it. We had not yet declared our scientific independence, were in fact thoroughly colonial in our methods of scientific teaching. Harvard received from an English benefactor, Thomas Hollis, the money for the foundation of her professorship of mathematics and natural philosophy; and English text-books were reprinted and used in some of our colleges till within the present century. The teachings of the colleges were probably traditional, and were not based upon independent research; but practical necessities soon required the employment of astronomical observers.

If you look at a map of Massachusetts you will perhaps notice the extremely rough way in which the State is divided into counties and townships. Clarksburg, near us, is six miles long from east to west, by two in breadth; Hancock, fifteen long from north to south; Cheshire has twenty-two corners. The boundaries of our counties are extremely irregular lines, and even those of the State by no means plain and simple. All this confusion of landmarks grew out of old-world habits; we have even an "enclave" in Cohasset, which belongs to Norfolk County, although surrounded by part of Plymouth.

Boundary disputes came up everywhere in the colonies; the people of Bennington, New Hampshire grantees, fought the New Yorkers, who in their turn appear to have established an outpost on the Connecticut River. Many colonial grants had been based upon parallels of latitude and meridians of longitude; I was myself called in, fifteen years ago, to assist in determining a Canadian boundary line, which was a continuation of a meridian through Illinois.

In 1767 the proprietors of Maryland and Pennsylvania sent to England for two astronomers to settle the parallel of latitude between the two colonies. In Massachusetts a similar parallel had been wrongly run; to this mistake we owe the inclusion of the village of Williamstown in Massachusetts instead of Vermont. The astronomers who were called in to fix the Pennsylvania boundary were Charles Mason and Jeremiah Dixon; and these were, so far as I know, the first trained observers ever employed in the United States. Mason had been Bradley's assistant at Greenwich; and the German whom I have mentioned has discovered, by the handwriting in the original books, which observations were made by

him, and which by Bradley and the others. He seems to have been an excellent observer. He had afterwards made many scientific journeys, and had done much by calculation to improve the lunar tables. Dixon was of course Mason's assistant, and is less known.

The work done by these two astronomers was the first piece of accurate measurement in this country, and perhaps it included the first parallel of latitude ever run out as a boundary.

It is not easy to cut one's way through the forest, to spend the nights in watching the stars and the days in moving on through the woods; to carry on horse- or mule-back the most delicate instruments, and watch, (I can almost say), every step of the beast, to see if he gives the chronometers any jar; to make the most refined calculations under the most difficult conditions. It is easier to deal with mathematical formulae by a warm fire in a pleasant room, or even to watch the stars in a well-appointed observatory. But practical astronomy of the kind brought here by Mason and Dixon is useful in all distant explorations, and is admirably adapted as a training for young observers. We have since had much of it in this country, and in our scientific development it has been of inestimable benefit.

About the same time an American astronomer, David Rittenhouse, was making a reputation. On the father's side Rittenhouse was Dutch; his family were paper-makers from Arnhem on the Rhine in Guelderland. He was self-educated; had read Newton's Principia and the other necessary mathematics, and taught himself the clockmaker's trade. Those were the days of the tall hand-made clocks, now so much prized as ornaments; and their construction was a matter

requiring much skill. In 1767, Rittenhouse, born the same year as George Washington, was in the prime of life, and may have indulged hopes of making the boundary survey for his native State, Pennsylvania. But he was only a colonist; the proprietors employed him in some preliminary rough work, but sent "home" as the phrase is, for their astronomers. It should have been Mason and Rittenhouse, rather than Mason and Dixon; Mason indeed found America much to his taste, and returned and settled in this country.

In 1769 came the transit of Venus; that phenomenon which occurs twice in a century only, and to most parts of the world is visible but once during that time. Some of us remember it in 1882, when astronomers were sent all over the world; I visited the party sent from Germany to Hartford, Conn., and was much impressed with their less haste (but more speed) than is natural to the American observer. I had previously learned the same lesson from engineer officers in our army. But in 1769 the transit was the only good means of finding the earth's distance from the sun; a distance which has fluctuated between ninety-two and ninety-six millions of miles since my remembrance. It is now pretty well settled as between ninety-two and ninety-three millions; but a hundred and twenty years ago it was rather uncertain. Rittenhouse built a little observatory near his house at Norriton, Pa., and was of great help to others, who observed the transit in and near Philadelphia. The event caused much interest in astronomy, and added to the impulse which it received from Mason and Dixon's labors.

In later years Rittenhouse was much employed as a boundary commissioner; among other work of this kind our own West line along the ridge of the Taconics was settled by his

efforts; it has been lately resurveyed and found as well done as was to be expected from his instruments.

He was also an early inventor of the "collimator," a device for obtaining a meridian mark without going far away; it has lately come back from Germany, where it was re-invented, and is now employed in the Field Memorial Observatory.

In general science the two ablest colonial Americans were undoubtedly Benjamin Franklin and Benjamin Thompson. Franklin, as we all know, drew the lightning from heaven, and proved its identity with electricity. His services as a diplomatic agent in France were greatly helped by his scientific reputation; returning to America he was instrumental in founding the two early academies of science, the American Academy at Boston, and the American Philosophical Society at Philadelphia. Both these have done useful work, recorded in their Memoirs and Proceedings. Thompson was so unfortunate as to be a tory; not a bitter one, but yet enough to make him an exile, and a great loss to his country. He served in the English army, went afterwards to Bavaria, where he laid out the "English Garden," the fine park of Munich — it should have been called the "American Garden"— and then to France. In his peregrinations he was knighted as Sir Benjamin Thompson, and afterwards ennobled as "Count Rumford." In his old age he did not forget his native land, but left a part of his fortune for prizes to American investigators of light and heat, and another part for a Rumford Professorship at Harvard.

After the Revolution the first great astronomer of this country was Nathaniel Bowditch; born in 1773, and dying in 1838, he had the fortune to be brought up and to live in free America. He came of a family of shipmasters; had but few

opportunities of education, but gave his whole leisure as a mechanic's apprentice, to learning. When a young man he went to sea as a supercargo, and continued his mathematical studies on long India voyages; he learned Latin and French for the sake of the sciences. When twenty-nine years old he went to the Cambridge commencement; his ship was then wind-bound in Boston Harbor, and he heard to his utter surprise that he was made a Master of Arts.

At that time he had edited for America John Hamilton Moore's Navigation; its errors were so many that he re-wrote the entire book, and published it as "Bowditch's American Practical Navigator." The work became famous, and brought him in a modest fortune. By and by he was able to give up his seafaring life and enter on business at Salem, afterwards at Boston; meanwhile he continually corrected and improved the "Practical Navigator," so that it has long been the best book of its kind in the English language.

While successful in business, owing to strict method and sterling integrity, he was able to do much to further astronomical science. He observed eclipses, meteors, comets; calculated the orbits of these bodies, learned German in order to read the writings of Olbers and others on such subjects; and finally translated and published at his own expense the great treatise of Laplace on "Celestial Mechanics," with important additions from the works of the German astronomers. Meanwhile other French mathematical books of a more elementary character had been translated and published at Cambridge, as well as by the West Point professors. The military school was established early in the century, but received its chief development after 1817. During our Revolution we had employed continental engineers, Kosciuszko among them, and the

French Revolution had brought others to this country, some of whom became instructors at West Point. The French mathematics thus supplanted the stiffer English text-books, including Euclid, both at West Point and some of the colleges; and John Farrar, professor at Cambridge, led his pupils pretty far along in these studies.

Among Farrar's students was a young friend of Bowditch's, Benjamin Peirce, who soon showed a profounder mathematical ability than Bowditch himself. Other Bostonians interested in astronomy were Robert Treat Paine, a very enthusiastic and careful observer, who went over sea and land to observe solar eclipses, and determined latitudes and longitudes in many places, especially in Massachusetts, with sextant and chronometers. Simeon Borden made, about half a century ago, a triangulation of the State, which with Paine's latitudes and longitudes, gave a measure of the earth, which is by no means seriously inaccurate, considering the smallness of the instruments, and the moderate size of the territory.

Meanwhile the United States had begun a general survey of its coasts. Early in the century there came hither a Swiss astronomer and geodetic surveyor, F. R. Hassler. He was for a time professor at West Point: he became known as a man of high scientific attainments and practical ability, and began the survey after furnishing a better detailed plan for it than any of his competitors. This work, however soon lost favor with Congress, was interrupted for years, and begun again in 1832. He was successful in training up an able set of assistants, and was able to make a good beginning of the Survey. Meanwhile the West Point school had educated many promising pupils, and the engineers of the army began to be skilful in carrying on astronomical and other higher

surveys, taking up the work of Rittenhouse and other civilians, and improving on the former methods.

One excellent astronomer among the army officers was James D. Graham, who had much the same characteristics as Paine, whom I have mentioned. Both were admirable sextant observers, and, in general, could obtain very accurate results with very moderate instruments. Neither of them felt quite at home with the giant telescopes of modern times.

At Yale College a good telescope of moderate size was procured as early as 1832. In that year and the next occurred the great November shower of meteors, which happens two or three times every thirty-three years. The teaching power of Professor Olmsted, the telescope of five inches' aperture, the meteoric shower, and later Halley's Comet, seem to have aroused a good deal of astronomical enthusiasm at New Haven, and for a few years a number of the students turned their attention to astronomy.

The telescope would have done better service had there been an observatory; but it was set up in the tower of a college building, and rolled upon casters over an unsteady floor; few accurate observations were made with it. Of the mathematicians and astronomers graduated in those days, Mason and Stanley died young, Loomis and Lyman are still aged professors at New Haven, but Chauvenet, on the whole the most eminent, never returned to the college. He went into the United States Service as Professor of Mathematics in the Navy, and was one of the most important men at the Naval Academy founded by Secretary Geo. Bancroft. He removed to St. Louis and became head of the Washington University in that city, where he died. Chauvenet was the son of a Frenchman who married in America, and combined

in many ways the characteristics of the two nations. From his father, he received a careful training in the French language, and his books exhibit much of the elegance of the writers of that nation. His "Spherical and Practical Astronomy" is probably the best book on the subject in any language; I see it quoted abroad as well as at home; it is an inexhaustible store of the best mathematics of the subject.

Half a century ago, then, American astronomy in a practical form was beginning to show itself. About Boston there were three or four amateur observers of a good deal of skill. One of the best was the chronometer maker, William Cranch Bond, who had a little private observatory in Dorchester; Paine and Bowditch were others. Peirce and Lovering were young professors at Harvard. Bowditch had published his translation of the Mécanique Céleste, copies of which he generously gave to libraries and to mathematical students. At New Haven there was much interest, and some effort to make valuable observations; and the college was graduating more young mathematicians than it had usually done.

In the government service were skilled observers, who had at their command fairly good instruments of moderate dimensions; but there was no permanent observatory at Washington, or elsewhere in the country. About this time Captain Wilkes's exploring expedition sailed on its long voyage around the world. Wilkes will be remembered by his seizure of the Trent, rather than by his earlier reputation as a scientific explorer. In these voyages it was intended to determine the longitude of many places by observations of the moon, and it became necessary to make similar observations on land at known places. A young naval officer, Lieutenant Gilliss, was instructed to make such observations. His

transit instrument, of very modest dimensions, was set up on Capitol Hill at Washington, under a temporary shed; and a fine clock was placed along with it. There Gilliss observed very regularly from 1838 to 1842.

Similar observations were made at Dorchester by W. C. Bond, under contract with the Government. But these beginnings of astronomical works, which led later to the establishment of observatories, were themselves subsequent to the building of the Williams College Observatory by Albert Hopkins. Almost from its foundation our College has had instructors who were lovers of natural phenomena, and science has in a modest way been long encouraged here. Chester Dewey, an early professor in this College, was the first scientific lecturer I had the pleasure of hearing. He was teaching physics and chemistry in a little medical school in Vermont, and I well remember how I was interested in a lecture on heat which I was allowed to attend. In the very early time, years before, of his professorship here, he taught all the sciences of the course, or nearly all; his specialty, later, was a branch of botany. Eaton and Emmons will also be remembered among our professors, as men of original views; but I think we are indebted to Albert Hopkins for much of the impulse toward the direct study of nature which has long prevailed here.

When Mark Hopkins was made President in 1836, his brother Albert had been some years an instructor in the College. In 1834 he had gone abroad to procure philosophical apparatus, and learn something of the European methods of investigation and teaching. At that time the impulse to scientific study which was contemporaneous with the French Revolution, and which had continued through the Napoleonic

wars, had spread over nearly all Europe. Even England had submitted to the continental ways of studying mathematics, — not quite completely, but still far enough to give a good deal of community of spirit between the English and foreign astronomers. In Germany and the Baltic provinces of Russia there were astronomers — Bessel, Struve, Gauss, Argelander, Encke,— who taught practical astronomy as a university discipline, and employed their observatories as practical means of impressing their theoretical lessons on the pupils. In England, and I think France, it was not so; theoretical mathematics was studied to the completion of the course in it, and was followed by the more abstract parts of astronomy.

The pupils of the astronomers before mentioned were not very many, but yet enough to keep the subject alive, and gradually diffuse a knowledge of it through the higher schools. At Cambridge, in England, the mathematical instruction had little by little taken the form of training men to pass examinations in the mathematics, and the senior wranglership, or first place in mathematics, was the goal of the ambition of the ablest men in the university. Our American courses were in part copied from the English studies of the last century, and were, little by little, modified to suit our circumstances. But their adaptation was not perfect, partly because no definite idea was dominant.

At Dr. Mark Hopkins's entrance upon the presidency of Williams, in 1836, a new spirit soon manifested itself. His scheme of studies was well thought out, and the leading idea, that of making man himself the subject of study for the Senior year, tended to give the course a certain roundness and distinctness to the mind. He taught physiology as an introduction to philosophy; a natural thing for a trained physician

to do, and it was a very advanced idea at the time. This new impulse seems to have led to the building of the Observatory; both brothers probably thought it would make, as it has done, the study more vivid and interesting.

I need hardly enlarge here upon the character of Albert Hopkins. All Williams men know how strong in all respects he was; what an admirable helper to his more widely celebrated brother; how high and pure his aims, how great a factor he was, especially in the religious life of the College, for so many years. But even as a young man he was deeply imbued with the love of nature. There was no one who did more to interest his students in all the Creator's wonderful works. To his initiative is due the first scientific expedition sent from this College; for many years he was the leader in the exploration of these hills, which has been so fruitful both of health and of knowledge to the generation now middle-aged.

I presume that in 1834 he had arranged for the purchase or construction of the transit instrument and clock, the latter still in active employment as a time keeper for ordinary as well as for scientific purposes.

During his visit to Europe, too, he undoubtedly learned much of the interest in the return of Halley's comet, expected to occur within a year; and on his coming back he soon began the construction of an observatory. He built this chiefly at his own expense, and partly with his own hands; he even worked in the stone-quarry, getting out its materials.

It is a quaint little structure, but well planned and built for its purpose. The ground plan is that of a central portion surmounted by a dome, with two wings; very much like many observatories then and now. It is still used for gazing at the heavenly bodies, and is useful for the students in a variety of

ways. Its replacement for scientific purposes by an observatory upon a new site is due to the situation, now partly surrounded by trees; so that if the attempt had been made to mount in it the beautiful meridian instrument which Mr. Field gave the College in 1881, it would have been necessary to sacrifice many of the ornaments of the campus. The authorities were naturally unwilling to do this, and preferred to provide more room in a retired spot, and Mr. Field's great kindness was again manifested in providing the building,— the "Field Memorial Observatory." In 1869 he had founded the Professorship, and so gave Professor Hopkins release from other duties in his declining years.

The Hopkins Observatory was, as I have implied, the first in this country of a permanent character. Every such building previously erected or arranged for the purpose, was temporary in its very nature; there is no one of these now standing. Of course Rittenhouse, and that admirable observer the elder Bond, and other astronomers, had their private observatories in connection with their houses; but our Professor was the first actually to erect an observatory for public purposes. It was chiefly built in 1837, and dedicated on June 12, 1838; it is the *fiftieth year* from this which we now commemorate.

I do not think that in so generously devoting his savings to the College for this purpose, Professor Hopkins intended making regular courses of observation. For this his duties were too multifarious; his teaching included at first all the mathematics and natural philosophy of the course; and practical astronomy is a profession by itself, usually requiring for its highest perfection the devotion of a life-time. There are those, it is true, who have become distinguished astron-

omers while engaged in other professions,— the musician, William Herschel, the physician, Olbers, the shipmaster and man of business, Bowditch. But Professor Hopkins felt his true mission to consist in moulding character by the influence, direct and indirect, of the religious life; he was ever an active missionary.

His idea was rather that of using the Observatory to make tangible his teaching of the science; to give the instruction emphasis and force by actual sight where the abstractions were too deep for the pupils' minds; and also to interest one or the other bright student to use the instruments for himself, and thus awaken slumbering talent.

In the history of American astronomy this first establishment of a permanent observatory is a striking landmark. Up to that time all efforts to establish one had failed. People were too materially inclined, it would seem, to encourage such an ideal science. What was known of astronomy seemed far distant. Even the practical every-day uses of the science were overlooked or despised; I have read a surveyor's petition to Congress, begging to be released from the requirements to run due north and south lines; he lost too much time in watching for the Polar Star on foggy evenings; he thought lines run in any direction would do as well, provided they were tolerably straight. Time-pieces were kept roughly correct by "noon-marks" and other rude contrivances, and few felt the need of more accurate subdivision.

Congress had sternly set its face against the establishment of an observatory. The Coast Survey received its money on condition that none of it should be spent for any such purpose. The Survey had, it is true, collected transit instruments and telescopes, with which observations could be made;

and the army engineers had also their little plant of similar apparatus.

Lieutenant Gilliss, as I have before mentioned, made astronomical observations from 1838 to 1842, in a cabin on Capitol Hill, and was enabled to show more or less of his work to visiting Congressmen, and to dispel in some degree their prejudices. In 1838, also, an observatory was begun at Hudson, Ohio, under Elias Loomis, who observed pretty regularly for several years. A year or two later Sears C. Walker and E. O. Kendall built the Central High School Observatory of Philadelphia, and began observations and computations.

At West Point the need of an observatory was strongly felt, and Professor Bartlett went abroad in 1840 to order instruments and visit observatories. On his return, rooms were provided for the instruments in the new library building of the school; in this we see the effect of the prejudice which would not allow a separate observatory to be paid for out of public money.

Finally, in 1842, Congress authorized the building of a "Depot of Charts and Instruments;" the present Naval Observatory at Washington under a disguised name. It is one of the faults of our system of government, that appropriations are often made without a very distinct knowledge on the legislators' part of the use for which the money is intended. The astronomers of the observatory were at first to be naval officers; partly of the line, lieutenants and passed midshipmen, partly the so-called professors of mathematics. These were a small corps of educated men, whose duties had been to go to sea and teach the midshipmen navigation; their number became needlessly large when the Naval Academy was founded, and the midshipmen concentrated at Annapolis;

so that several of the "professors" were ordered to the observatory. The corps is still kept up, and has contained many distinguished astronomers.

The next large observatory founded was at Cambridge. In 1843 appeared a remarkable comet; probably a fragment of a much larger body which at some past time has been broken up by its near approach to the sun. It went within 100,000 miles of the sun's surface, and was subject to enormous heat and powerful attraction. It was visible in full daylight, as was the comet of 1882, which some of you may remember; probably not the same as the comet of 1843, but another broken piece of the same original body. In the study of the comet of 1843, Professor Benjamin Peirce was much interested, and he used his great eloquence to impress on the Boston men of wealth the need of a large observatory.

Some time before this Mr. W. C. Bond had been invited to remove to Cambridge with his instruments, and a house belonging to Harvard College had been fitted up for him, so that there might be an observatory at Cambridge, and, nominally at least, under college authority. Peirce's appeal was ably seconded by J. Ingersoll Bowditch, son of Nathaniel, and himself an astronomer of no mean attainments, but better known as an active business man in his father's footsteps. He has always shown a lively interest in the observatory and all scientific enterprises about Boston; and by the efforts of Prof. Peirce and Mr. Bowditch the money was raised for a great telescope.

The order was given in Europe for a refractor fifteen inches in diameter, equal to the largest then existing. It is still a comparatively large telescope; but our own opticians, as we shall see, have gone far beyond its dimensions. The

Harvard College Observatory was built in the years before 1846, and the great telescope came in 1847. A few years later the indefatigable Peirce was laying the scientific foundations of the American Nautical Almanac; while his increasing reputation attracted about him a few mathematical students of high ability from various parts of the country, in addition to his college pupils.

Lieutenant (afterwards Admiral) C. H. Davis, a family connection of Peirce, was the one who succeeded in persuading Congress to pay for the calculation of an American almanac for the sailors, and release us from a dependence upon foreign nations, which might be troublesome in case of war. The office of the Nautical Almanac was established — at first in Cambridge — under Davis's business management and Peirce's scientific control.

Meanwhile the Coast Survey had gone steadily on; after Hassler's death it was placed under the superintendency of Professor Bache, of Philadelphia, a great-grandson of Franklin, and a distinguished graduate of West Point. From Franklin he seemed to have inherited both scientific ability and executive and diplomatic capacity to a high degree.

In the quarter century which elapsed between the first beginning (1836) of our Observatory and the outbreak of the civil war, American astronomy had made great progress. The work of an astronomer involves certain professional habits of care and accuracy, whether he be chiefly an observer or a calculator; and an abstract mathematician does not always make the best practical astronomer, for the latter must attend to certain every-day matters which the former sometimes neglects. The best cure for absent-mindedness and day-dreaming which I know, is to observe star-transits; for the

stars are extremely punctual; if the observer wanders off into regions of abstract thought, the star will not wait for him, it is always in its proper place at the exact second.

Then, there are mechanical operations to be performed which sometimes involve a good deal of manual labor; and the man who has to do this must be skilled in the science; even the subordinates in an observatory need education; they must have a good deal of mathematics at their fingers' ends.

One great advance in mathematics during the present century is the theory of the errors of observation which we owe to Gauss, and which shows us how to distinguish between good observations and bad, and even between blunders and the necessary imperfections of our senses.

By 1861 this country had acquired what I may call a school of astronomers. That is, there were many observatories, — public and private — with far too little money for their maintenance in regular activity it is true, but with here and there an observer or calculator who knew how to use the instruments and the results of observation. Any young man who, like Rittenhouse or Bowditch, felt himself impelled to study astronomy, could find instructors, and after sufficient training could usually get remunerative employment. He could also gain the ear of a public interested in such things; by the better newspapers, if what he had to say was of a popular character; or by the scientific journals of America or Europe, if he had something new and original for the specialists. There was also an astronomical journal of much merit, published by the zeal and munificence of its editor, Dr. Gould.

Some of the early achievements of our astronomers have been of permanent use to the science. Of these the most important are the two connected inventions,—the chrono-

graph, and the telegraphic method of determining longitude.

The chronograph is the instrument used in the "American Method" of observing transits. It is practically a telegraphic ink-writer, or other register; connected with a clock, it marks the seconds on a sheet or tape of paper; and the observer, who has to find the exact time of any astronomical phenomenon has simply to press a telegraph key near his instrument, and the time is recorded. Similar instruments have since been used to measure the speed of thought, and compare one man with another as to quickness of apprehension, or willing; so that astronomical methods have thus been introduced into psychology. In the old way of taking transits, the observer, while looking through the telescope, was obliged to count his time, second by second; to do this without mistake, and write down the small fractions of the second, is much more difficult than to observe by the American method.

Very soon after Morse's inventions, and the establishment of a few telegraph lines, Walker, Loomis, and other American astronomers, used them to send time from one observatory to another. We can readily see that by the earth's steady motion on its axis, difference of time is equivalent to difference of longitude; twenty-four hours correspond to the whole circuit of the earth, and every hour to fifteen degrees. All our railways are now run by Greenwich time, with a change in the whole hours only; thus seven o'clock of railway time here is simply twelve o'clock at Greenwich; and our trains are run on the time of the seventy-fifth meridian.

Before this system could be inaugurated, our astronomers must find out how their observatories were situated with respect to the Greenwich meridian; or at any rate to *some*

meridian. The telegraph was, as I have said, first employed in America for this purpose, after many trials of other methods had been made, with partial success. Before the ocean cable was laid, the position of Harvard Observatory from Greenwich had been determined with great care by the Bonds; their method of exchanging times was to send a great many ships' chronometers backwards and forwards between England and America.

Our astronomical progress had been most considerable in those branches which are of practical importance; but yet there were those who gladly took hold of more ideal problems. The American mind is peculiar; partly from heredity, partly, I suppose, as influenced by the greater command of circumstances possible in a free country. The American is ambitious in intellectual things, if once his interest is aroused; and he frequently cannot reconcile himself to take a second place.

A striking example of this quality is seen in the life of Alvan Clark, the great optician, who has lately gone from us at a ripe old age. In my boyhood I met him, then a modest portrait painter of middle age, who had begun to interest himself in the making of object glasses, and to hope that he could by-and-by compete with the German opticians in telescopes of moderate dimensions.

One of his early object glasses, of half the diameter of the Cambridge telescope, is that belonging to the equatorial of the Williams College Observatory, given by that constant friend of the College, Amos Lawrence. Mr. Clark did not then construct the machinery of entire telescopes, and the mounting is by an inferior mechanic, and not very good.

It was not long before Mr. Clark's reputation increased, and he received some orders from England. His acquaintance with the English amateur astronomer Dawes, gave him opportunity to learn what a very sharp-sighted, careful observer desired in his object-glass,— for Mr. Dawes was extremely critical,— and he was finally enabled to surpass even the German makers in the precision of the images seen in his telescopes. At this point he was assisted by liberal capitalists to set up a larger establishment, and, with his sons, to enter upon telescope-making on a greater scale.

His first great telescope, belonging to the Chicago Observatory, was completed in 1865; the object-glass, larger than any then existing, had been made several years before. From that date till his death in 1887, he was actively at work, though already an old man; and my last visit to him two years ago, was made in his workshop, where he was busy on the greatest object-glass now existing, one of more than twice the diameter of the Harvard telescopes. This glass, that of the Lick Observatory, in California, was preceded by one which gave him a great triumph. He had displaced his competitors' instruments in America, wherever increased dimensions were called for; but the great Imperial Observatory of Russia, at Pulcova, near St. Petersburg, was in the market for such an instrument.

The Struves, father, sons, and grandsons, have long been known as among the most careful observers. But the present head of the family became convinced that in his own special line of work he needed a more powerful telescope; and what he learned of the performance of the Clarks' glasses led him to give them the order for the optical part of the instrument. The mechanical portion was made in Hamburg, by the Rep-

solds, who are the greatest mechanicians of the world, the makers of our fine meridian circle.

The last twenty-five years have brought much material advancement to the science in this country. It is hardly possible to go deeply into it; in many respects it is a repetition of the earlier history. Observatories have been founded in new places, sometimes with means for their maintenance, at other times without. Some of the older ones have received large accessions of invested funds, and have thus been enabled to do more; this is notably the case at the Harvard Observatory, which has been given the handsome fortunes of Robert Treat Paine, the amateur observer of the earlier time, and of Uriah Boyden, an inventor of turbine wheels, who had been greatly aided by Benjamin Peirce's knowledge of the higher mathematics. Boyden's bequest requires the establishment of a mountain observatory; his trustees have placed it under the Harvard management, so that the mountain observations will be calculated at Cambridge. The ability and success of our younger astronomers in handling deep and difficult problems has been proved entirely adequate; I think we have never lacked the men, but it is only lately that they have found education and encouragement.

Many able astronomers, too, have come to us from foreign countries, among whom is our Nestor, Dr. Peters, who is with us on this occasion. I dare not attempt to say how many small planets he has discovered within the last quarter of a century; but his other work has been enough by itself to give his observatory a high reputation both at home and abroad.

It is pretty plain that the public mind has changed its attitude toward astronony. We now find more general intelligence on the subject; more disposition to believe in astronomers; more encouragement to those of them who are still struggling with difficult problems; more pride in their achievements. European scientists now come occasionally to see what is doing here; the profession of an astronomer is a recognized career.

What then shall be the future of our science in this country?

Two things are plain: first, that the great benefactions to colleges help all the sciences; and second, that original investigation is much more prominent as a feature of college work than ever before.

We have giant telescopes enough in this country; Alvan Clark's sons will doubtless keep up the supply of large instruments; but we need to look at the science a little more deeply on the intellectual side. I would remind you that our college studies are largely traditional; that astronomy, along with geometry and music, was one of the studies of the old Quadrivium, and that perhaps a recasting of our courses may be possible and beneficial.

I am a believer, as are other college instructors of some eminence, in the disciplinary value of astronomy as an independent study. The mathematics have their value, and a very high one it is; but the lower mathematics, especially arithmetic, have been overdone in a certain direction; I mean that of riddles, puzzles,— brain-spinning, as the Germans call it. While our boys and girls are given problems to solve which quite exceed their thinking powers — I don't suppose I could ever have gone successfully through Greenleaf's National Arithmetic till I had graduated from College — their minds are quite undeveloped in the power of observation, and they are often imperfectly trained in the four ground rules, espe-

cially in decimal fractions. So far as my own experience goes, the best mathematical training is that which deals with tangible objects; the abstractions should have a sensible basis.

I would then have the observation of the common phenomena of nature accompany the study of arithmetic and geometry in the common schools. The pupils should learn to watch the barometer and thermometer, sunset and sunrise, the phases of the moon, the motions of clouds; they should know the pole-star, Ursa Major, Orion, the Pleiades, Leo, the Scorpion; should learn to distinguish between the stars and the planets, to watch for the aurora borealis, to note the colors of the rainbow. The high school, or college preparatory school, should always have its telescope, and some simple means of accurately keeping time; a few notions of scientific astronomy should not fail to be inculcated.

In college, the professor of astronomy should have time and opportunity to interest even the Freshmen in his study; I do not mean that he should give them formal teaching, this may well be reserved for later years. But he should have a variety of instruments, some of the inexpensive kind made now-a-days, for gazing purposes; or old telescopes, out of fashion for observation, so that one or another of the students could watch the heavens for himself. Informal instruction may always well precede the more formal; and occasional observatory evenings with interesting objects could be arranged, so that a good part of our classes might enter on the regular study of the science with some distinct notions.

To introduce the work I have described into our common schools will take a long time, perhaps a generation. But it seems a waste, when we open any mathematical school-book

and find in it so much that refers to a merely imaginary world; and then to hear from business men and college professors that all this training leads to nothing definite; and, when the young men are nearly through their college course, to find them unable to tell the points of the compass in a strange place, or even in their own college town; or not aware that when the moon is full it rises very nearly at sunset.

The colleges have begun to do their part in teaching the teachers. Courses in practical astronomy are now given in many institutions; the instruments can be used, and the results of observation calculated, by the few who elect this subject.

It is more difficult than it ought to be to go very far in these studies, because the habit of applying the earlier mathematics to tangible objects is unformed. The young man is at first confused when you tell him that he must measure the sides or angles of his spherical triangle. He has always thought a spherical triangle to be an abstraction. Moreover, he cannot always handle even his arithmetic with facility; and certainly, again and again I have found mistakes in difficult calculations, which the student himself could not detect, to lie in carrying wrongly in addition or subtraction.

A return to nature in our whole method of education — even in the elementary teaching of Greek, that bugbear to some so-called educators — is now actually going on; the next generation will reap the benefit. Could I have learned Greek and Latin as my colleagues are now teaching them, I should have had many more interested hours; and other subjects, history, biology, physics, are now taught by better methods.

The college observatory of the future, in this country, should contain a good many moderate instruments; none very gigantic, but some of that handy size which is best adapted to advance the science. A giant instrument renders the observer helpless, if he has not a file of soldiers, or other servants, to help him move the machinery; one which he can just conveniently handle leaves him free to work, and always shows him objects enough to observe. If he have a trained eye, that in itself is equivalent to an increase in the size of his instrument.

I hold that in a strong college, independent work, to advance the science, should be going on; the students will be benefited by the closer contact with realities which is thus gained. Moreover the teachers themselves can better be kept from rusting, or falling into a treadmill round; they can be in the current of scientific thinking, even if their problems be modest. But along with the best instruments to show the refinements possible, there should be samples of simpler and cheaper ones, partly for the independent work of the pupils, partly for the exploration of the heavens to gain immediate communion with nature in its grander aspects, partly to show the future teachers what their schools can afford. The general framework of mathematical training will gain largely, the more it is connected with modern scientific applications, and thus the more closely it is conjoined with nature.

I may be permitted here some quotations from a modest but deep thinker, whose little work Emerson recommended Carlyle to read, the late Sampson Reed, of Boston. The book is called "Observations on the Growth of the Mind."

Mr. Reed says:— "If it were desired to make an individual acquainted with one of the abstract sciences, this might best

be effected by leading him gradually to whatever conduced to the growth of those powers on which a knowledge of these sciences depends; by cultivating a principle of dependence on the Divine Being, a purity and chastity of the affections, which will produce a tranquil condition, of all things the most favorable to clear perceptions; by leading him to an habitual observation of the relations of things, and to such continued exertion of the understanding, as, calling into use its full powers without inducing fatigue, may impart the strength of the laborer without the degradation of the slave; in a word, by forming a penetrating mathematical mind rather than by communicating mathematical information. The whole character and complexion of the mind will thus be gradually changed, till at last it will become (chemically speaking) in its very nature an active solvent of these subjects." This return to nature, in our teaching, was thus eloquently recommended in 1826; it is gradually becoming accomplished in the scientific studies of our better colleges.

Astronomy deals with immensity of space; who can conceive the enormous distances at which the stars are from us? The nearest one is forty millions of millions of miles from us, or nearly that; the light is six or seven years in coming from it. The little star which was seen to blaze out in 1866, may really have burst into flame before the discovery of America by Columbus; the dim cloudy spots which we see in so many places, and are tempted to call world-stuff (nebulous matter is the usual name), are so far that no human mind can do more than guess their distance.

It will be well, I think, if we can interest our pupils — and I do not mean college students alone — in the contemplation of the heavens as well as in the scientific study of their

motions and phenomena;—if the telescope can become an indispensable piece of apparatus in the highest school of any locality, even a village. This study should go hand in hand with the ordinary common observations of the nearer things around us.

But looking back over the last half century of scientific progress in America, we have every reason to be hopeful for its future. America is the great republic; every man is born equal to every other; if the bricklayer's son exhibits the genius of the century in mathematics, he needs no petty Grand Duke's favor, but will be recognized and helped by his fellow citizens and the organizations for study which have grown up during our few centuries; while the experience of the past fifty years has shown that these organizations will have an unexampled growth in the next fifty years so far as predictions in any human affairs are possible. American astronomers and American instrument makers — few indeed half a century ago — are now known by reputation and respected in the whole civilized world.

The first permanent American Observatory is still standing, to show by its modest dimensions how great a growth has been possible in half a century.

NOTE.—In the *Nation* for August 16, 1888, Professor Love of the University of North Carolina gives an account of an early attempt in 1831 to build a college observatory at that institution, which ought not to be forgotten. Dr. Joseph Caldwell, then President of the University, was the builder; and it was only the imperfection of its construction and the death of Dr. Caldwell in 1835 which prevented its mention in the histories of American astronomy. Professor Loomis seems not to have known about it when writing his "Progress of Astronomy"; and Dr. Caldwell appears to have had successors who were not interested in astronomical science. In fact, the observatory was burned in 1838, and the ruins employed to furnish materials for a kitchen.

MSH # 20145

END OF
TITLE